



Status and plans for NP04

Filippo Resnati (CERN)

ProtoDUNE@Neutrino Platform

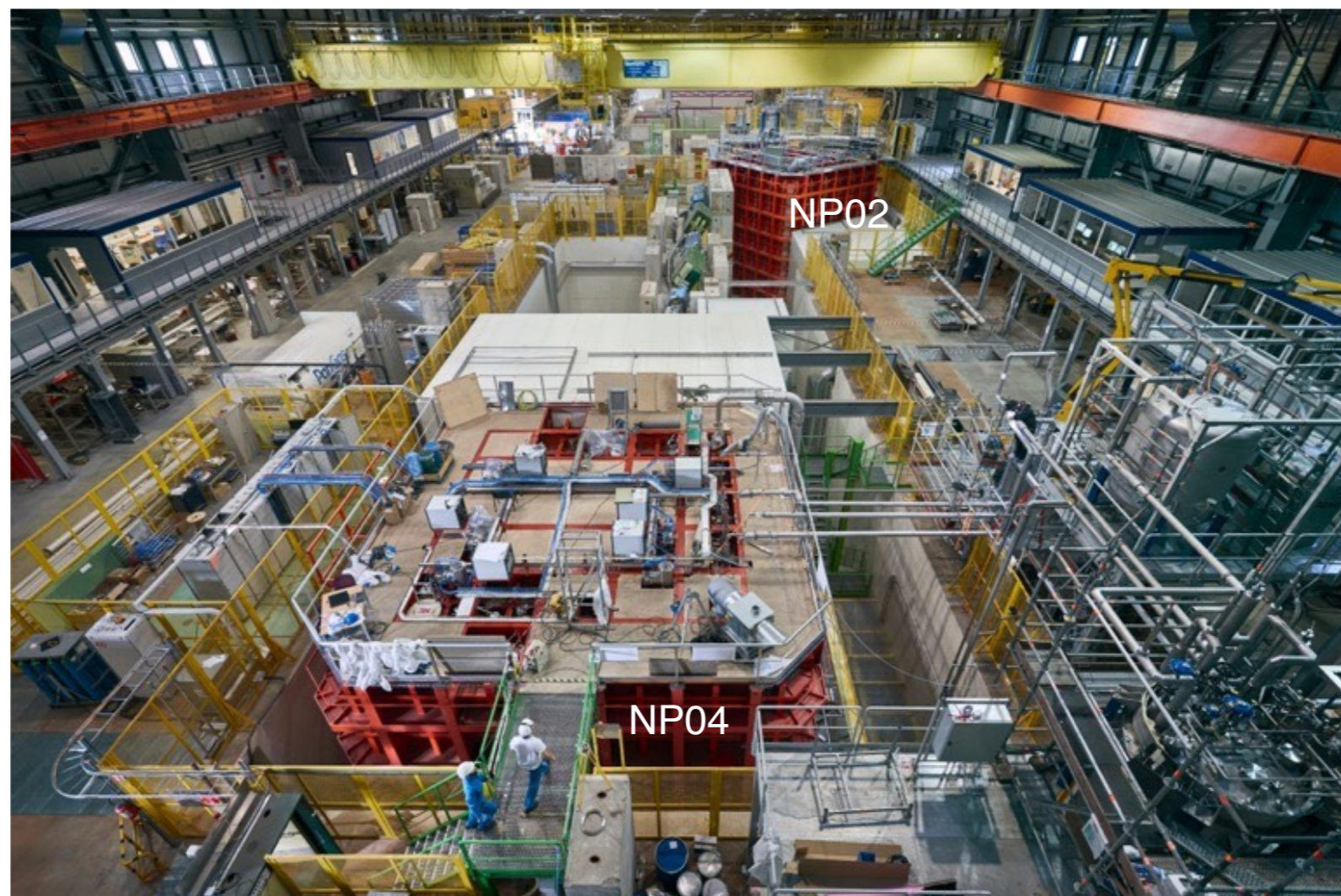
Two 750 t LAr TPC prototypes of $\sim 8 \times 8 \times 8 \text{ m}^3$ at EHN1 in the CERN North Area
Validation of design, production and installation of all DUNE FD components at full scale

NP04 Horizontal drift: 2018-2020

- Charged particle beam + cosmic rays
- Event reconstruction, full analysis
- Neutron calibration, Xe doping, HV tests
- Phase-I decommissioned in 2021
- Phase-II installed in 22-23, operation in 2024

NP02 Vertical Drift: 2019-2021 operated as Dual Phase

- DP concept with charge amplification in gas phase
- Demonstration of operation at with 6 m drift 300 kV
- Evolving into SP *Vertical Drift* from late 2020
- DP detector components decommissioned in 2022
- VD demonstrator installed in 2023, operation in 2024



Filling order

In the past several months recommendations from SPSC, LBNC and DUNE EB to prioritise the program of the NP02 VD detector (functional integration still to be demonstrated):

- Initial plan to expose both NP02 and NP04 to beam in 2024 was no longer plausible in fall 2023 due to the lack of availability of LAr

Dedicated Task-Force appointed to evaluate in pros and cons of two alternative options

- 1) Fill first NP04 for a beam test in spring 2024 before transferring the LAr to the NP02

- 2) First fill of NP02 (without beam) to complete integration tests before the end of the summer

Report from the Task-Force released at the end of 2023

- The task-force urges the Collaboration ... to start as soon as the Liquid Argon becomes available purging and filling NP04, allowing to complete the critical validation program of the VD detector components and of its integration.

- This recommendation is based on the need of minimizing all the risks that may incur either during production, integration and installation, and that may impact the performance of the final DUNE VD detector during operations.

- It is the opinion of this Task-Force that the impact on the construction schedule of the VD detector is minimal or none.

Liquid argon procurement

No availability of LAr in 2022. In 2023 price estimates ~4x prices of 2021:

- Followed price development in 2023 through informal estimates from European suppliers
- Tendering process initiated in October (invitation of 13 both EU and US suppliers)
- Tendering completed successfully. Price accepted after negotiation
- Cost of LAr covered by US LBNF/DUNE
- TE-CRG group started the recommission of the cryogenic system in January

LAr procurement contract signed in January.

Kickoff meeting held on Friday 26th of January.

First two trucks on the 20th and 22nd of February.

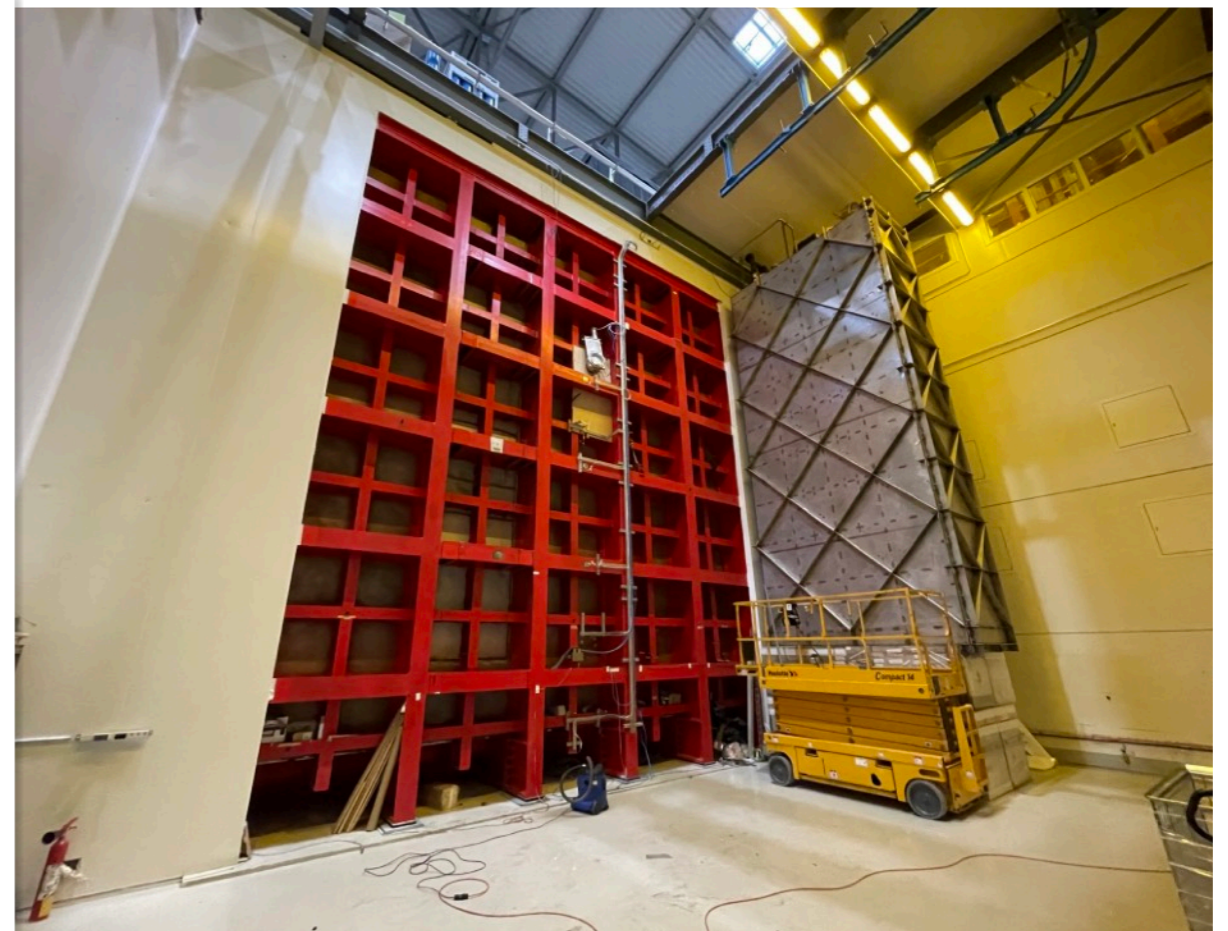
Nominal deliveries from the 4th of March:

- 5 containers/week by train to Lyon, and by truck to CERN
- 2 trucks/week in addition
- max two deliveries/day
- lower delivery rate than expected <160 ton/week instead of 200 ton/week
- 6 weeks of filling
- purification to reach ~3 ms ($100 \text{ ppt O}_2^{\text{eq}}$):
 - * 2 weeks from 2 ppb O_2^{eq} ,
 - * 3 weeks from 10 ppb O_2^{eq}

NP04 TCO closure

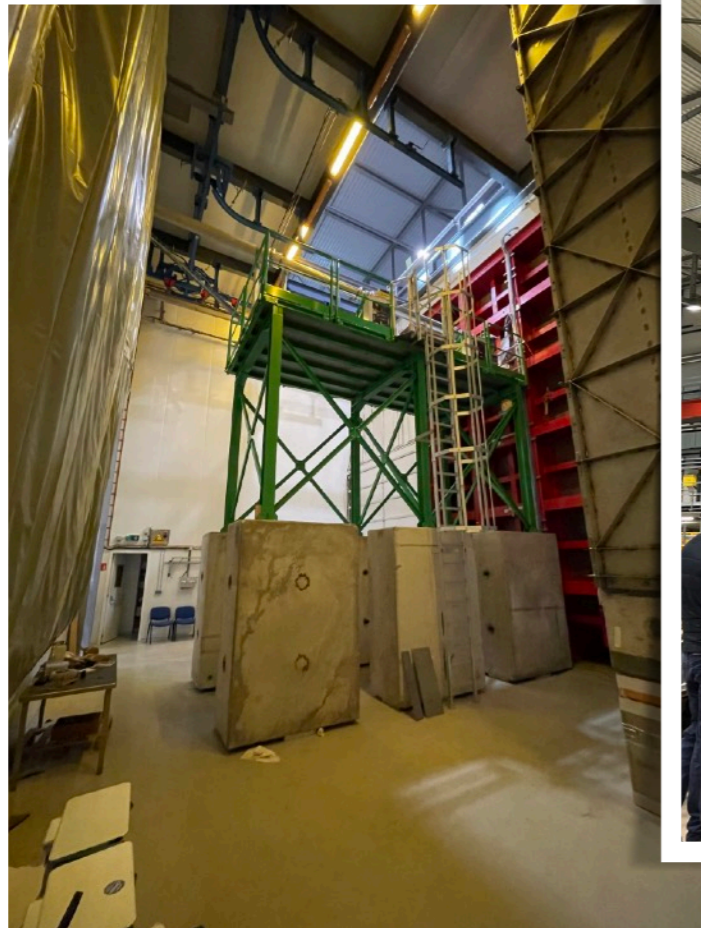
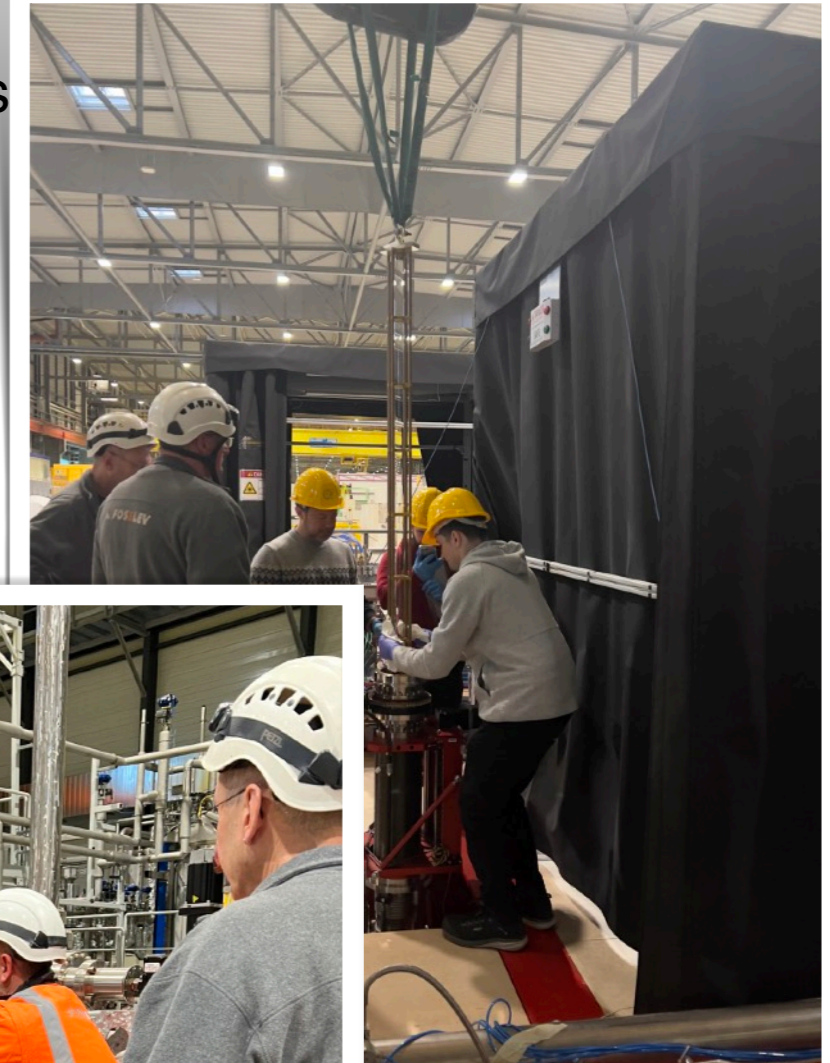
Completed before the end-of-the-year break

- Setup a physical separation and appropriate ventilation to avoid dirt into the detector
- Installation of tertiary barrier, insulation, secondary and primary barriers
- No leaks found after reparation of one found during the leak tests with He
- Insulation space under moderate vacuum
- Zone cleaned and dirty room dismantled



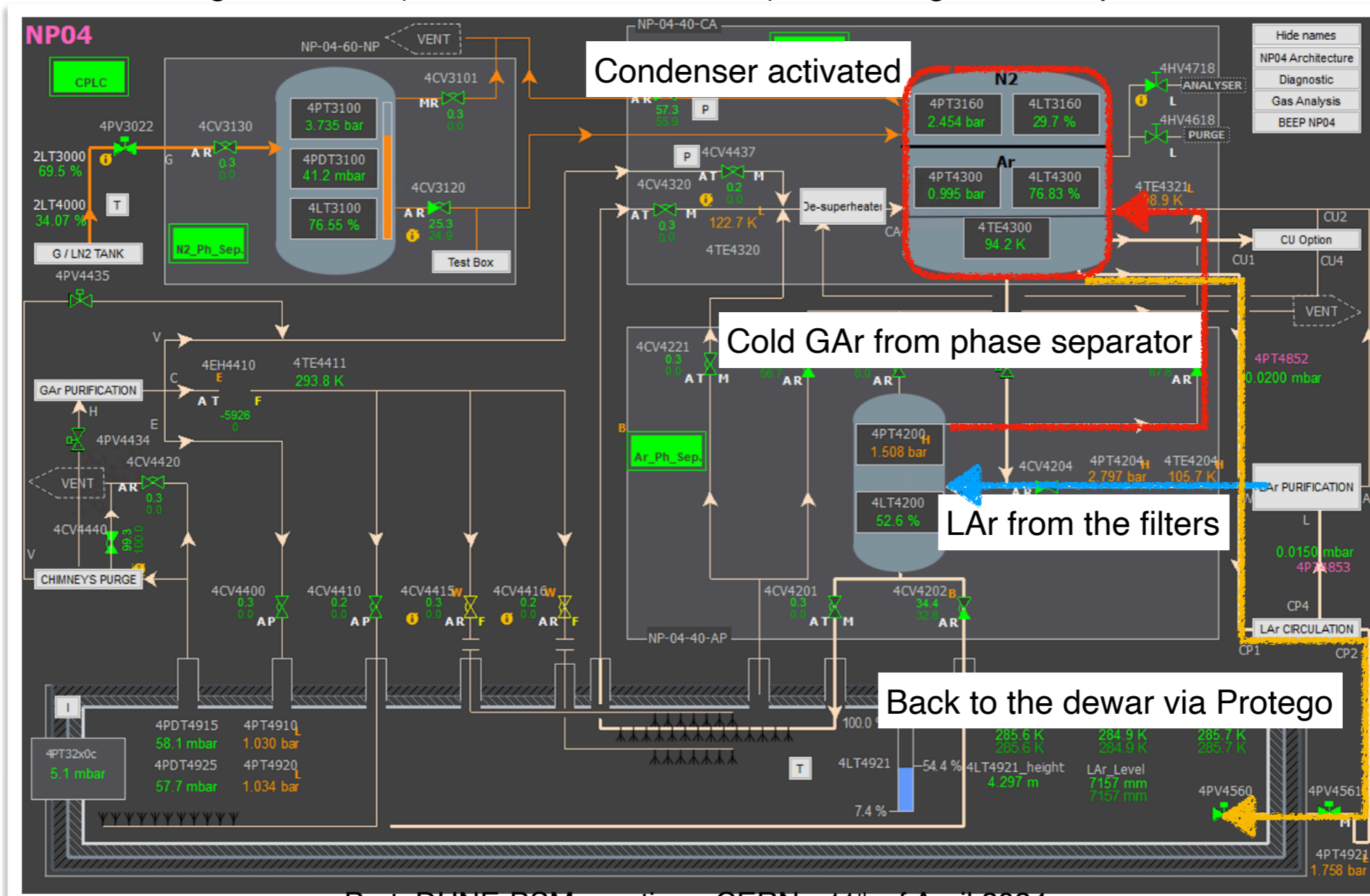
Steps after TCO closure

- ✓ - HV test (up to 15kV)
- ✓ - Removal of the false floor, installation of the missing ground planes
- ✓ - Installation of the cameras and lights
- ✓ - Installation and alignment of the Ionisation Laser Periscopes
- ✓ - Installation of the Purity Monitor
- ✓ - Removal of APA protection panels and false floor
- ✓ - Installation of the ^{207}Bi source on cathode
- ✓ - Sealing of all flanges
- ✓ - Remove of access scaffolding
- ✓ - Installation of CRTs
- ✓ - Installation of beam platform

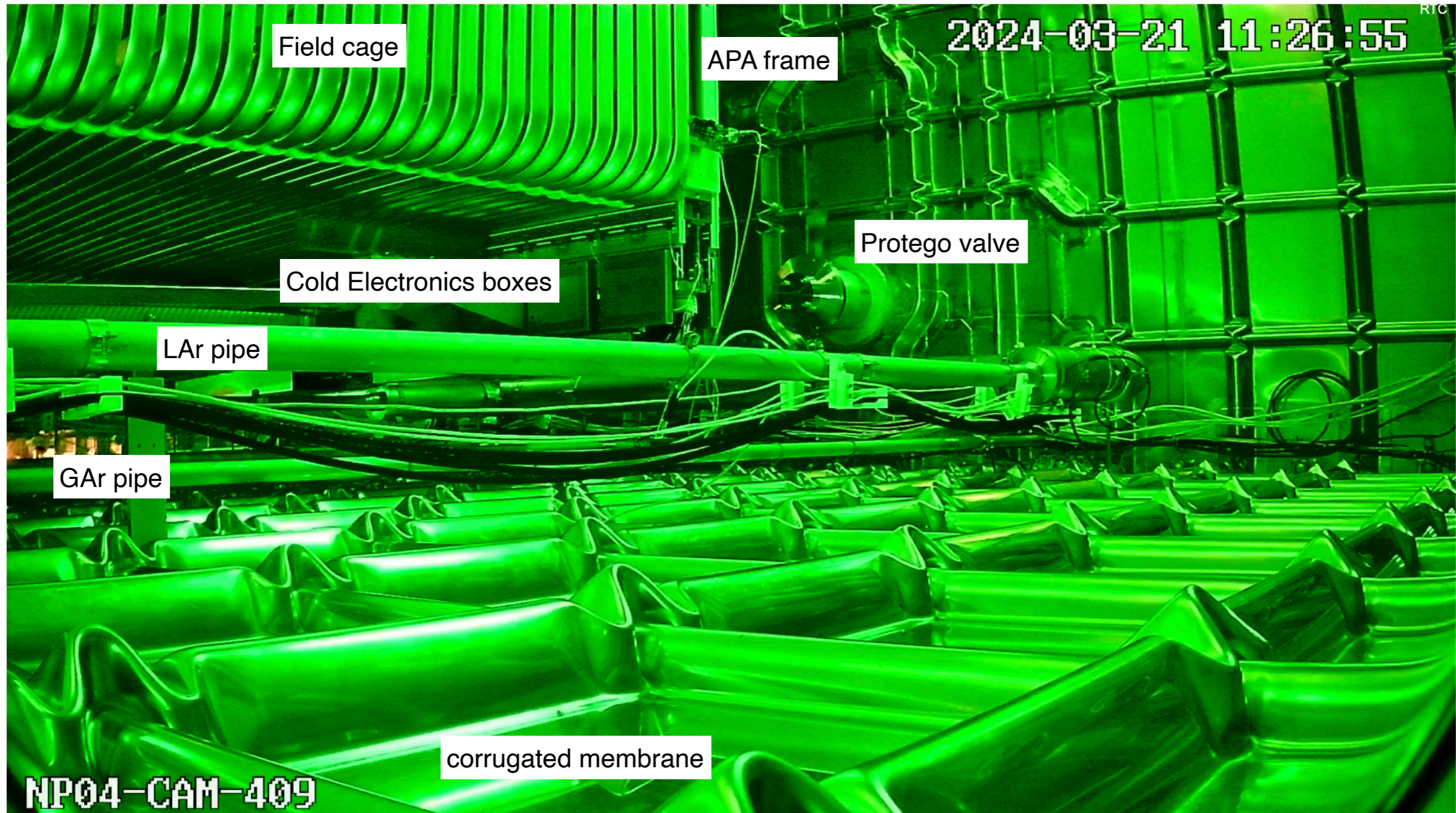


Status of the filling

- ~685 tons of LAr delivered to CERN
- 430 ton (~4.3 m) in NP04
- Level almost at the beam plug (still under -good $O(10^{-6}$ mbar)- vacuum)
- 20 ton in outside tank
- Argon also used to fill NP02 cold box and cooldown filters after regeneration
- Activated the condensation of boil-off from phase separator
- Filter regeneration (Cu and and mol sieve) both for gas and liquid



From camera immersed in LAr

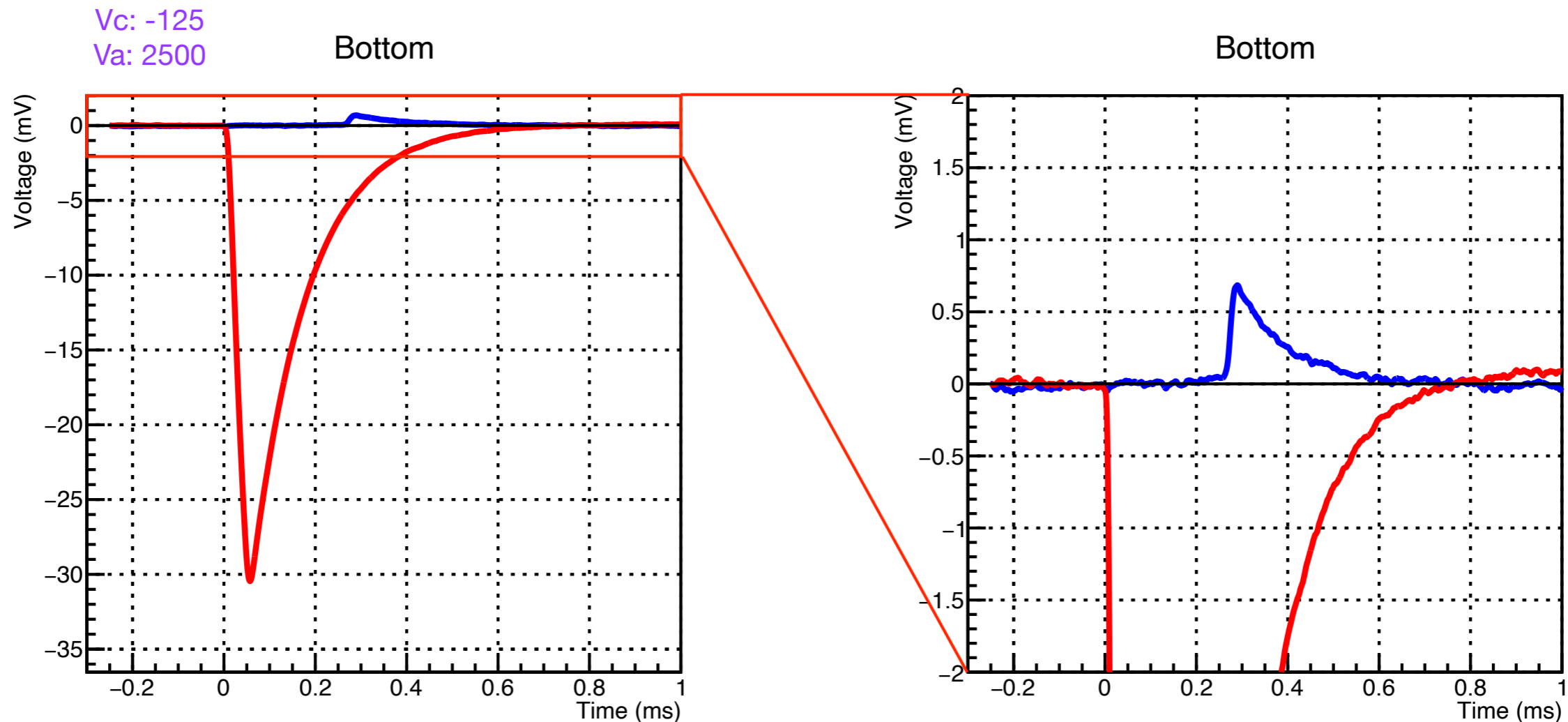


Purity

Very good purity to start with. Purity decrease since Mar 22nd -> Filters regenerated

Slides from Wenjie Wu

First look in liquid argon (Bottom PrM, Mar. 22)



Qa/Qc ~ 0.0198
tau ~ 59 us
~ 5 ppb

Beam request

Beam request for 8 weeks (before end of August) submitted to the SPSC in December '23
Beam request for NP02 will be done for 2025

High precision measurements of hadron-argon cross sections are very important to understand

- final-state interactions of hadrons within the argon nucleus,
- the secondary scattering of primary hadrons produced in neutrino interactions.

Two of the largest systematic uncertainties in long-baseline neutrino oscillation experiments.

Integrate the data taken in 2018 concentrating on low momenta (~ 1 GeV/c) and including both polarities (in 2018 only positive polarity was taken). Main goals:

- Benchmark the performance of the detector (PID, calorimetry with charge and light)
- Characterisation of the detector response and energy resolution to pions and protons
- Inclusive and exclusive pion-argon and proton-argon cross sections
- Differential cross sections for a number of different final states as a function of the child particle kinematics

PS-SPS schedule

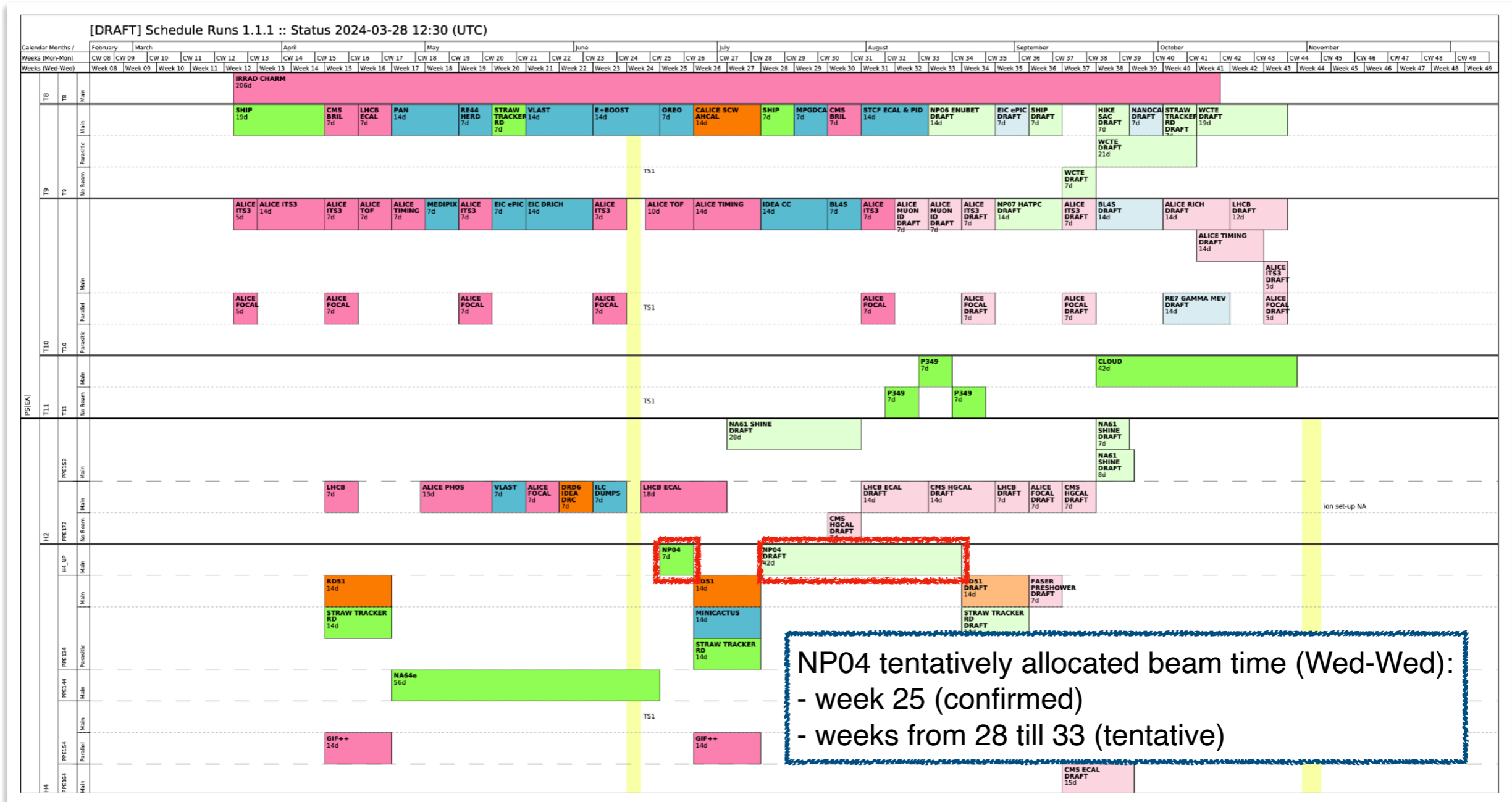
SPSC was very supportive and tentatively NP04 is allocated with 7 weeks beam time.

Injector schedule: Proton run was confirmed to be 5 weeks longer

Latest SPS schedule available <https://ps-sps-coordination.web.cern.ch/ps-sps-coordination/>

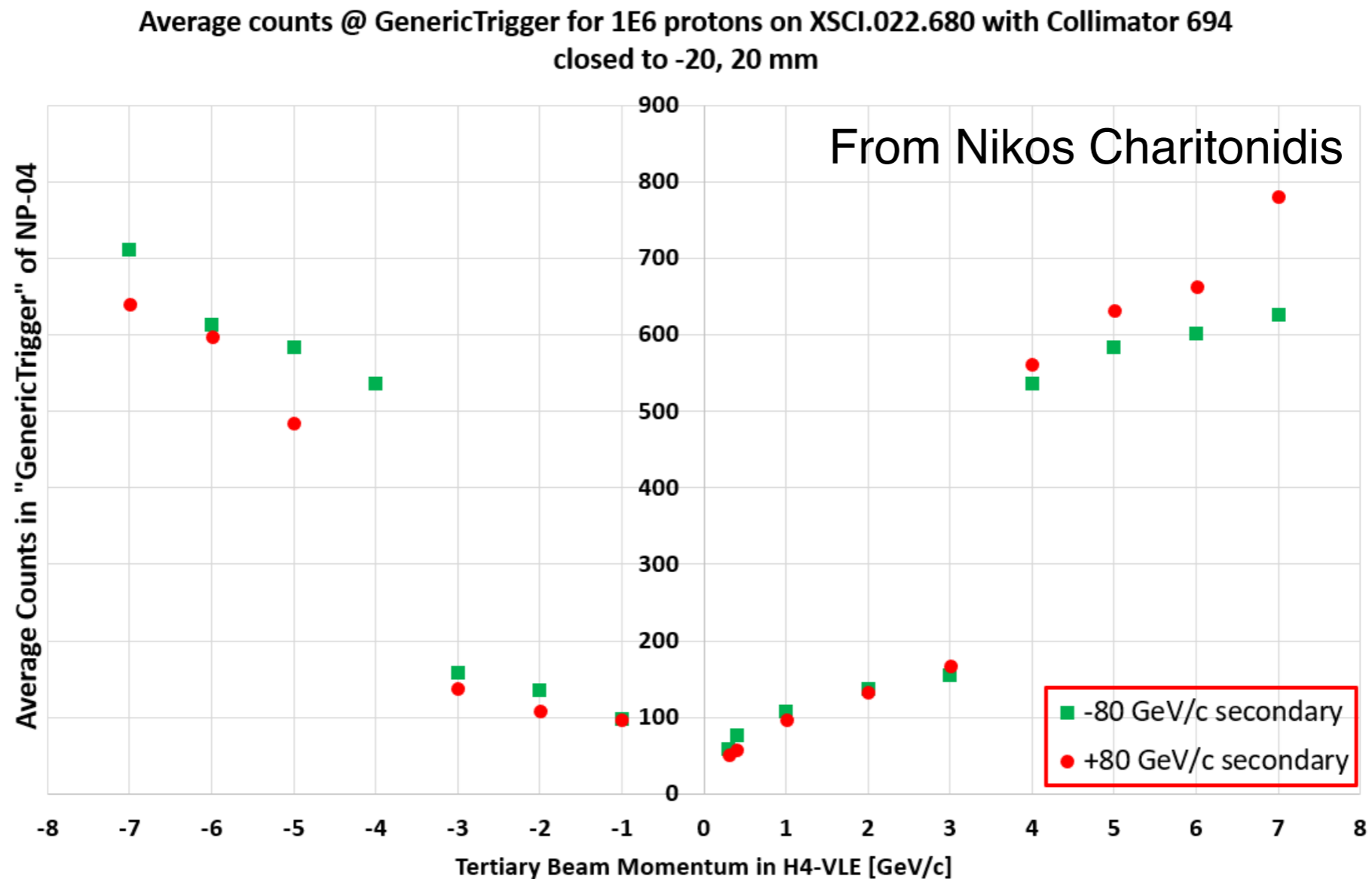
Confirmation of first week (week 25) of beam time. We expect beam from the 19th of June.

The rest of the beam time (weeks from 28 till 33) is still in DRAFT and may be subjected to changes



PS-SPS schedule

Beam commissioning and beam instrumentation commissioning finished yesterday.
Successful two weeks long period to revamp equipment used last time more than 5 years ago.
Confirmation that rates are little influenced by polarity of beam on target: decouple from beam in H2.



2024 proposed timeline

Proposed schedule is to run first NP04 in spring and part of summer before transferring the Ar to NP02
The exact date of the begin of the Ar transfer depends on NP04 test advancement, beam, and NP02 readiness

